



## Rotation Angle Detector

### FIELD OF THE INVENTION

5           The present invention relates to a rotation angle detector for use in detecting a rotary angle of a steering wheel on a vehicle and the like.

### BACKGROUND OF THE INVENTION

          With progress of higher-performance vehicles made in recent years,  
10       there have been proposed various rotation angle detectors (hereinafter called “RAD”) for detecting a rotary angle of a steering wheel (hereinafter called “SWH”). An example of such RAD is disclosed, for example, in Japanese Patent Non-examined Publication No. 2002-206910.

          A conventional art RAD will be described with reference to FIG. 5.

15       On a circumference of rotary member 1, there is formed spur gear portion 1A. Rotary member 1 has engagement portion 1B to engage a shaft of SWH (not shown) inserted into a center thereof. Insulative resin-made detecting member 2 has a substantially planar top face. Spur gear portion 2A provided on a circumference of detecting member 2 is in a meshing  
20       arrangement with spur gear portion 1A on rotary member 1. Detecting member 2 has a cylindrical columnar protrusion 2B formed at a center of its underside. Protrusion 2B has magnet 3 mounted at its end by performing such an operation as insert molding.

          Circular columnar shaft portion 4, made of a metal, is fixed by insert  
25       molding or the like to a center, i.e., a rotational axis, of detecting member 2, as projected upwardly.

          Axes of shaft portion 4 and magnet 3 are each arranged substantially in

alignment with the axis of detecting member 2.

There are provided a plurality of wiring patterns (not shown) on both sides of wiring board 5 disposed substantially parallel to the underside of detecting member 2. Further, magnetic sensor element 6 is mounted on a face opposite to detecting member 2. Magnet 3 and magnetic sensor element 6 arranged opposite to each other constitute sensing device 7.

Further, there is provided wiring board 8 connected with wiring board 5 via lead wire 9. On wiring board 8, there is formed a control device 10 constructed of electronic parts including a microcomputer. Control device 10 is connected to an electronic circuit (not shown) on a vehicle body by way of a connector (not shown).

Further, cylindrical supporting member 11, made of an insulative resin, is fixed onto a top face of wiring board 5. Cylindrical supporting member 11, while surrounding protrusion 2B, supports the underside of detecting member 2 for rotation. Upper cover 12, made of an insulative resin, has shaft support 12A protruded downwardly from its underside, with shaft support 12A having a diameter slightly larger than a diameter of shaft portion 4 of detecting member 2. Shaft portion 4 of detecting member 2 is inserted into shaft support 12A to be supported thereby for rotation.

Rotary member 1, wiring board 5, wiring board 8, and the like are covered by insulative resin-made case 13, insulative resin-made side cover 14, and upper cover 12, so that these components are kept in place to configure RAD.

As SWH is turned in the above described configuration, rotary member 1 is rotated accordingly. Following this rotation, detecting member 2 with its circumferential spur gear portion 2A meshing with circumferential spur gear portion 1A of rotating member 1 also rotates taking, as a center of

rotation, shaft portion 4, which is supported by shaft support 12A protruded from upper cover 12. As detecting member 2 rotates, a magnetic field around magnet 3 mounted at the center of detecting member 2 changes. Then, this change in the magnetic field is detected by magnetic sensor element 6, and a detection signal with a substantially triangular waveform is output to control device 10. Thus, it is arranged such that control device 10 detects a rotation angle of rotary rotating member 1 on the basis of the number of waveforms and a voltage value of the detection signal from magnetic sensor element 6. An angle of rotation of SWH can thus be detected. However, when such conventional RAD is mounted on a vehicle, there are also placed other equipment or parts on top of RAD. Accordingly, a height from a top face of detecting member 2 up to a top face of upper cover 12 is limited and, hence, length L1 of shaft support 12A formed between the top face of upper cover 12 and the top face of detecting member 2 becomes short. As a result, shaft portion 4 supported within shaft support 12A tends to show play or looseness during rotation.

Such play or looseness causes undesirable rotational deflections of magnet 3 provided at the bottom end of detecting member 2. Thus, conventional RAD is confronted with a problem in that errors are liable to be produced in a detected angle of rotation.

The present invention is addressed to such a problem in the conventional art, and it is an object of the invention to provide RAD with high detection accuracy.

## SUMMARY OF THE INVENTION

The present invention provides a rotation angle detector including a rotary member, a detecting member for rotating in conjunction with rotation

of the rotary member, a cover having a shaft support formed thereon for rotatably supporting a shaft portion of the detecting member, and a sensing device for detecting rotation of the detecting member, in which the detecting member is provided with a recess surrounding the shaft portion, and the shaft support formed on the cover is extended into the recess.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of RAD according to an exemplary embodiment of the present invention.

FIG. 2 is an exploded perspective view of RAD according to the embodiment of the invention.

FIG. 3 is a voltage waveform diagram in RAD according to the embodiment of the invention.

FIG. 4 is a method of detecting a rotation angle in RAD according to the embodiment of the invention.

FIG. 5 is a sectional view of conventional RAD.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An exemplary embodiment of the present invention will be described with reference to the accompanying drawings.

Component parts like those described in the BACKGROUND OF THE INVENTION will hereinafter be denoted by like reference numerals and detailed description of the same will be simplified. Further, the drawings are schematic ones and do not show each position exactly.

(Exemplary Embodiment)

Rotary member 1 is made of an insulative resin such as polyoxymethylene (POM) and polyphenylene-sulfide (PPS). On a

circumference of rotary member 1, there is formed spur gear portion 1A and, in a central portion thereof, there is provided engagement portion 1B to engage a shaft of SWH (not shown) inserted therein.

Insulative resin-made detecting member 21 is provided, on its  
 5 circumference, with spur gear portion 21A arranged in a meshing relationship with spur gear portion 1A on rotary member 1. Detecting member 21 is further provided with a cylindrical columnar protrusion 21B at a central portion of its underside. At an end of protrusion 21B, there is mounted magnet 3 by being insert molded therein .

10 As magnet 3, any type of permanent magnet can be used. For example, a ferrite magnet, samarium magnet, and neodymium magnet can be preferably used. Circular-columnar shaft portion 22, made of a metal, is fixed by being insert molded or the like at a central position, i.e., a rotational axis of  
 15 detecting member 21, so as to project upwardly. Further, in a top face of detecting member 21, there is provided recess 21C surrounding a periphery of shaft portion 22. Axes of shaft portion 22 and magnet 3 are each arranged substantially in alignment with the axis of detecting member 21. On a face opposite to detecting member 21, there is disposed wiring board 5 with magnetic sensor element 6 mounted thereon. As magnetic sensor element 6,  
 20 such a magneto resistive element as InSb is preferably used.

Magnet 3 and magnetic sensor element 6 arranged opposite to each other constitute sensing device 7. Wiring board 8 having control device 10 thereon is connected to wiring board 5 via lead wire 9. Control device 10 is connected to an electronic circuit (not shown) on a vehicle body through  
 25 connector 23. Further, cylindrical supporting member 24 made of an insulative resin such as POM and polybutylene-terephthalate (PBT) is fixed onto a top face of wiring board 5. This cylindrical supporting member 24 is

arranged to surround protrusion 21B and supports an underside of detecting member 21 for rotation. Further, upper cover 25, made of an insulative resin such as POM and PBT, is provided with shaft support 25B protruding downwardly from its underside and having a through hole 25A slightly larger in diameter than shaft portion 22 of detecting member 21. This shaft support 25B is arranged to extend into recess 21C provided in a top face of detecting member 21 until its end abuts a bottom face defining the recess 21C. Shaft portion 22 is inserted into shaft support 25B to be supported thereby for rotation.

Rotary member 1, wiring board 5, wiring board 8, and the like are covered by insulative resin-made case 13, insulative resin-made side cover 14, and upper cover 12, so that these components are kept in place to configure RAD.

As SWH is turned in the above described configuration, rotary member 1 is rotated accordingly. Following this rotation, detecting member 21, with its circumferential spur gear portion 21A meshing with circumferential spur gear portion 1A of rotary member 1, also rotates with shaft portion 22 as a center of rotation.

At this time, length L2 of shaft portion 22 supported by shaft support 25B is made greater than length L1 of that in the conventional art example shown in FIG. 5 by a depth dimension of recess 21C into which shaft support 25B is extended. Further, since the end of shaft support 25B abuts a bottom face defining recess 21C, detecting member 21 can be rotated with reduced play or undesirable rotational deflections.

As detecting member 21 is rotated, magnet 3 mounted in the center thereof is also rotated. Changes in a magnetic field produced at this time are detected by magnetic sensor element 6. Then, a detection signal cycling with a

substantially triangular waveform gradually increasing, or decreasing, as shown in FIG. 3 is output to control device 10. Where angles of rotation are indicated by negative values, angles that are measured in a direction opposite to the direction in which these negative angles of rotation are indicated, are indicated by positive values .

Suppose now that the number of teeth of detecting member 21 is set to be, for example, one third of the number of teeth of rotary member 1, and magnetic sensor element 6 is adapted to detect one change in magnetic field intensity for every rotation of  $180^\circ$  of detecting member 21. Then, detecting member 21 makes three rotations during one rotation of rotary member 1, while, during one rotation of detecting member 21, magnetic sensor element 6 detects two changes in the magnetic field intensity. Hence, six voltage waveforms in a substantially triangular shape are successively detected as a detection signal. More particularly, for a  $60^\circ$  rotation of rotary member 1, one substantially-triangular voltage waveform is output from magnetic sensor element 6 and supplied to control device 10 as the detection signal. Then, control device 10, first, counts the number of waveforms of the detection signal to thereby detect an approximate angle of rotation of rotary member 1. Then, the control device 10 detects the accurate angle of rotation of rotary member 1 from this voltage value . For example, in a case where the angle of rotation is  $\theta$  as shown in the voltage waveform diagram of FIG. 4, then, first, the ordinal number of waveforms counted from a base point at  $0^\circ$  is two, and hence it is detected that the angle of rotation is between  $60^\circ$  and  $120^\circ$ . Then, RAD is adapted to detect that the accurate angle of rotation is  $90^\circ$ , for example, based on voltage value v.

In the present embodiment, as described above, while recess 21C is provided in the upper face of detecting member 21 to surround shaft portion 22,

shaft support 25B formed on upper cover 25 is extended into recess 21C. Thus, shaft portion 22 of detecting member 21 can be supported by shaft support 25B having an elongated span or dimension in an axial direction. As a result, play or undesirable deflections of shaft portion 22 occurring when it rotates within through hole 25A can be reduced, and undesired rotational deflections of magnet 3 provided at the end of detecting member 21 can also be reduced. Thus, it becomes possible to have a signal with small error detected by sensing device means 7 and to obtain RAD having high detection accuracy.

Further, since shaft portion 22 is supported by shaft support 25B along its elongated axial span or dimension, a load applied to an inner periphery of through hole 25A during rotation can be distributed.

Consequently, wear and tear on the inner periphery of through hole 25A due to rotation of shaft portion 22 can be reduced and hence the life of RAD can be extended.

As described above, according to the present invention, it becomes possible to provide RAD having undesirable rotational deflections of detecting member 21 reduced, and capable of making highly accurate detection.